POSITION OPTIMISATION OF GE DETECTORS IN NUCLEAR RESONANCE FLUORESCENCE (NRF) EXPERIMENT BY USING MONTE CARLO METHOD

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Abstract: Nuclear resonance fluorescence (NRF) supplies good information to study nuclear structure of isotopes. The main perquisite for excitation to occur, the incoming photon must have energy equal to one of the excited states of absorbing nucleus. After absorption of the photon, nucleus will have a transition to the excited state pertaining to photon energy and then the excited nucleus will decay back to the ground state by emitting a gamma ray that has energy equal to that excited state. This process is called nuclear resonance fluorescence (NRF). In this study, we estimated the optimum detector position by considering maximum photon-detector interaction and counted photon amount. It can be concluded that maximum photon fluence is recorded at the under of the NRF target.

Key words: Monte Carlo Simulation, Nuclear Resonance Fluorescence (NRF)

Introduction

Nuclear resonance fluorescence (NRF) is recognized as an effective method that provides reqired information for the researches on the dipole excitations of nucleus (Kneissl, 1996). Main developments in recent years of high-efficiency germanium detectors (HPGe) with great energy resolution, in connection with high-intensity bremsstrahlung photon beams, has provided the essential tools to study about electric dipole strength distributions. Moreover, nuclear resonance fluorescence (NRF) means the process of resonant excitation of definite nuclear states of a target nucleus by absorption of radiation. A simplified simulation of an NRF experiment shown in below.

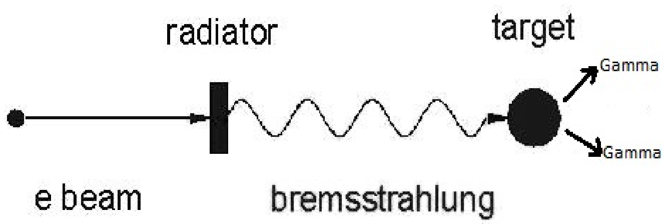

Figure 1 NRF Experiment

In recent years Monte Carlo (MC) simulations has been used frequently on NRF experiments (Jordan, 2005). As the basis of the current work was done by simulation program, it's function was to simulate the photon transport in a material environment. In this study, we used the MCNP4C program which developed in Los Alamos National laboratory. MCNP is capable to simulate with neutron, gamma and secondary gamma rays production and transport which occur as a result of neutron interactions (Hançerlioğulları, 2006). Material assignments and defining the geometry have an important place in MC simulation. In this study we defined the each material and experimental tools before simulation. As a procedure in simulation, an electron beam having a certain energy directed onto a radiator which has a certain thickness and assigned material (Rodenas, 2007). In this study we used 10 MeV electron-beam which interacted with radiator that composed of 2 mm Tantalum target. Calculations were separately carried out for 2 sample material. After this interaction bremsstrahlung photons directed onto a Uranium-238 and Cobalt-57samples shown in figure 1. Detectors that defined and positioned around sample counted the photon amount in five different point. A scheme of simulation with experimental tools is shown in figure 2.

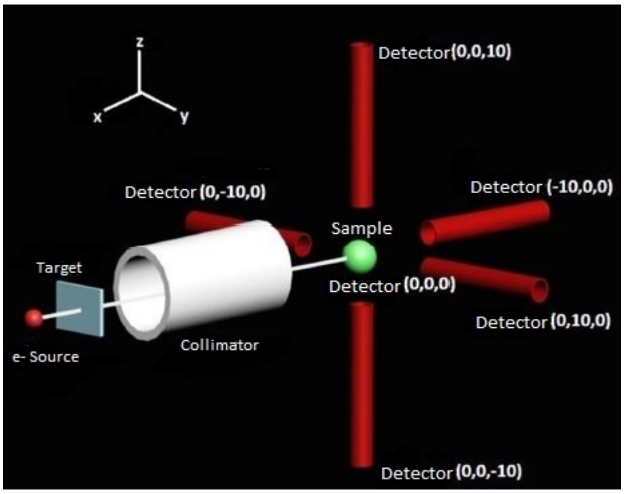

Figure 2 Experimental tools and detector positions

We can see from the table 1. that positions of the detectors located around sample in five different points. According to the coordinate axes as (x,y,z) five different points selected as (-10,0,0) (0,10,0) (0,-10,0) (0,0,10) (0,0,-10). In the coordinate axes the distance is given by cm. After the running program, detectors which located around Uranium-238 and Cobalt-57 sample started to count the scattered photons from nucleus with NRF process.

The Study

In recent years, MC studies has been used frequently in studies and researches on detection. Especially some studies also performed about relationship between detector position and detector efficiency (Baas, 2006). Since MC allow the detection at every selected point around target, we located the detectors on some points which definitely 10 cm from target in x,y and z directions. In this study we used the F4 tally for MCNP4C to achieve the average flux in a detector volume. The efficiency of the modeled detector is calculated. To obtain optimum detector position, we calculated each detector's total flux rates that in which point scattered photons are counted more.

Findings

The aim of this study was to find the maximum total flux from five detectors positioned around the target material. First simulation calculation was made for Uranium-238 sample and after that the same simulation calculation was made for Cobalt-57 sample. Total fluxes in the detector volumes which located in five different point for uranium-238 sample are shown in table 3.

Table 1: Total Photon flux rates by location (Uranium-238)

Location	Rate (%)	Axis Name
-10,0,0	12.73	-x
0,10,0	21.71	y
0,-10,0	21.89	-y
0,0,10	21.68	z
0,0,-10	21.99	-z

Table 2: Total Photon flux rates by location (Cobalt-57)

Location	Rate (%)	Axis Name
-10,0,0	12.73	-x
0,10,0	21.71	y
0,-10,0	21.89	-y
0,0,10	21.68	z
0,0,-10	21.99	-z

Conclusions

In this study we simulated the NRF experiment by using two different sample in MC code. It was found from this work that in both calculations maximum photon count obtained in –z (0,0,-10) point. However, figure 2 shows that -z point is perpendicular the electron beam line and underside of the sample target. We can see that scattering from the sample is much more to the underside of sample. This study shows that we can use -z point in future studies if only one detector location is needed while studying with MC. Of course, it can be also calculated more detailed locations around the –z point by considering changes with angles.

References

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